dark ground grows which gradually becomes more and more bright and at last, when thick enough (the thickness is generally of the order of a tenth of a millimeter), shows the colors of chromatic polarization. One can prove that these crystals are optically uniaxial; if the tube is turned so that the plane of a star is at right angles to the rays of polarized light the image of the star disappears.

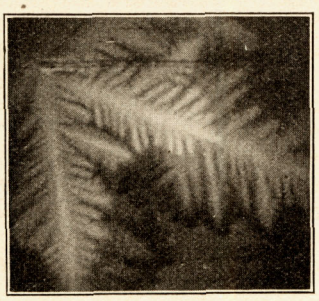

FIG. 3.

Precise measurements of these crystals will be made in winter when it will be possible to prolong their fugitive existence.

The size of the stars depends—at a sufficient undercooling, e. g., —2° C.—principally on the dimensions of the vessel with undercooled water. I often obtained single stars 8 to 12 centimeters broad.

RECENT EXTENSIONS OF THE CANADIAN METEOROLOGICAL SERVICE.

Director R. F. Stupart of the Canadian Meteorological Service in his letter of March 3, 1909, states that during the past summer he supplied barometers and a full equipment to the following stations in extreme northern Canada:

Fort McMurray,	latitude 56.40° N., longitude 111.25° W.
Fort Chipewyan,	latitude 58.41° N., longitude 111.10° W.
Hay River,	latitude 60.51° N., longitude 115.20° W.
Fort Simpson,	latitude 61.52° N., longitude 120.43° W.
Fort Norman,	latitude 64.57° N., longitude 125.00° W.
Fort Macpherson,	latitude 67.27° N., longitude 134.57° W.

where the observers will be paid for satisfactory service. This service has also just started two new stations in Newfoundland at Point au Basques and Burin. In the spring a station at Fogo and another on the Labrador coast will be put in operation, and the service then contemplates issuing storm warnings and forecasts for Newfoundland.—*C. A., jr.*

THEORIES OF THE COLOR OF THE SKY.

By EDWARD L. NICHOLS.[1]

Presidential address delivered at the New York meeting of the Physical Society, February 29, 1908.

[ABSTRACT.]

The author summarizes the various theories explanatory of the color of the sky, as follows:

1. The turbidity of the atmosphere would of itself give us a blue sky, but the ideal medium of Rayleigh would afford a distribution of intensities to which the actual sky rarely if ever corresponds.

2. Even were the atmosphere free from particles of dust, condensed water vapor or other extraneous matter it would not, according to Rayleigh's latest paper, be optically empty, to use the term employed by Tyndall, but would be blue by virtue of reflections from the molecules of the air itself.

3. If there were no other source of blueness, the color of the air according to Spring, would give us a blue sky by virtue of the selective absorption-color of various of its constituents. The objections to the adoption of this as a factor are obvious and are regarded by many writers as insuperable, but their arguments are not, in my opinion, conclusive.

4. Reflections from surfaces in a troubled atmosphere as pointed out by Hagenbach, would give us light from the sky increasing in intensity relatively to sunlight in proportion to the square of the wave-length. This is quite sufficient to account for the average blueness of the sky, but not for the intenser blueness frequently observed. It cannot therefore be regarded as the sole or most important factor.

5. Fluorescence as a factor of blueness of the sky cannot be definitely considered at the present time for lack of experimental data concerning it.

6. As regards the subjective or physiological factor it may be said that were there no other cause the sky would undoubtedly appear blue; for we still see it blue where measurements with the spectrophometer indicate a composition relatively much weaker in the shorter wave-lengths of the spectrum than the *average* composition of sunlight. In the present paper I shall, however, consider only the objective factors.

The problem of the color of the sky is stated as resolving itself into a determination of the relative importance of these various factors, the existence of all of which, with the possible exception of fluorescence, may be regarded as experimentally established. The phenomena of aerial polarization are believed to indicate beyond any doubt that the turbidity of the air is one source of the blueness of the sky. But while Rayleigh's masterly theoretical work—which calls for relative intensities of the reflected ray as compared to the incident ray varying inversely as the fourth power of the wave-lengths—has found complete verification in the studies of artificial media, spectrophotometric measurements of the sky itself have led to widely varying results. Thus, Zettwuch, who made many measurements at Rome, calls especial attention to the variability of the ratios. Crova, at Montpellier, whose measurements extend only between wave-lengths 0.635μ and 0.510μ, found the exponent to vary from 1.61 to 6.44. The author therefore seeks other sources than turbidity for the blue color of the sky.

Numerous measurements of the spectrum of the sky made by the author with a portable spectrophotometer show, in general, far greater relative intensities of the longer wave-lengths than one would expect from the theory of Rayleigh, which is based upon the assumption of an ideal turbid medium in which the diameters of all the particles in the medium are small as compared with the wave-length of light. The following are given as obvious causes of the discrepancies between theoretical and observed ratios of intensities:

(*a*) The presence of larger reflecting particles in the atmosphere, sometimes invisible and sometimes forming masses of mist or cloud.

(*b*) Absorption by transmission through the turbid medium itself.

(*c*) Illumination of the atmosphere by light reflected from the surface of the earth.

Curves of ratios based on observations taken at dawn and in the twilight after sunset, show but little variation from day to day in fair weather, and approximate closely to the ratio curves called for by Rayleigh's equations. During the day, while the sky-light taken as a whole increases greatly in intensity as the sun approaches the zenith, the actual intensities of the blue and the violet are much less affected than are the longer wave-lengths. When the moisture of the atmosphere condenses into cloud forms [cumulus] in the middle of the day, there is a marked diminution in the relative intensity of the sky-light at the violet end of the spectrum.

Evidence is found of the modification to a measurable extent of the character of the light of the sky by reflection from foliage, from clouds, and from the ground.

Reference is made to Pernter's study of the polarization of light emitted at right angles to the incident beam by emulsions of different colors. In general, the whiter the emulsion the less the polarization, which is also true of the sky. For a blue emulsion the green ray showed the greatest polarization, the blue next, and then the red. For a white emulsion the red ray showed the more polarization, there being a diminution toward the violet. Pernter found this also to be true of blue and white skies. The author found that the polarization of sky-light was sometimes greatest in the red, sometimes in the violet, sometimes in an intermediate color, and sometimes uniform for all wave-lengths, probably depending upon the size of the particles present in the atmosphere.

[1] Physical Review, Vol. XXVI, p. 497.

As stated above, Rayleigh's theory requires that the ratio of the intensity of the reflected ray to that of the incident ray shall vary as the fourth power of the wave-length, while Crova's measurements gave exponents varying between 1.61 and 6.44. From this fact, and further, since the author's observations often showed greater proportional intensity for the violet as compared with the red than for intermediate colors, he considers it probable that the blue color of the air itself and a blue or violet due to the fluorescence of ozone or other components of the atmosphere are to be regarded as possible factors in the production of the color of the sky, altho the data upon this subject must be considered incomplete and inexact.

The following is the author's summary:

1. That while there is good reason for regarding the sky as a turbid medium, the experimental study of the spectrum of sky-light affords evidence of a distribution of intensities which cannot be altogether accounted for by the assumption of an atmosphere conforming to Rayleigh's formula nor of a turbid medium containing coarser particles.

2. That the illumination of the atmosphere by selectively reflected light from the surface of the earth and from cloud masses and mist modifies the character of the light from the sky to an extent which, while perhaps not readily discernible with the unaided eye, is definite and unmistakable when the sky is studied with the spectrophotometer.

3. That the deviation of the observed distribution of intensities recorded by several investigators indicates a blue absorption color of the air or, since the preponderance in the violet appears to be variable in amount, the existence of fluorescence of some unstable factor of the atmosphere, such as ozone, or both.

The results of observations on the percentage of polarization of skylight at the point of maximum polarization made by me in Washington at the Weather Bureau may be summarized as follows:

1. Since the observations were made on cloudless days, the sources of illumination of the sky are considered to be (*a*) the scattering of light by particles in the atmosphere whose diameters are small as compared with the wave-length of light, (*b*) the scattering of light by relatively large particles, and (*c*) the reflection of both sunlight and sky-light from the surface of the earth.

2. When the ground is covered with snow there is a marked decrease in the percentage of polarization, due to increased reflection from the surface of the earth.

3. There is a diurnal variation in the measured percentage of polarization, the minimum ocurring at noon, with a gradual increase as the sun approaches the horizon, and a marked increase during the first few minutes of twilight following sunset, which may be attributed to relatively less reflection from the ground than from the particles in the atmosphere as the zenith distance of the sun increases.

4. The percentage of polarization decreases as the general atmospheric absorption increases, but apparently not by a simple law.

These results, which will be published in full in Vol. 2, Part 2, Bulletin of the Mount Weather Observatory, appear to be in accord with the summary given by Nichols.—*H. H. K.*

DUSTSTORMS IN TEXAS.

A correspondent calls attention to the fact that it is commonly believed in southern Texas, that whenever duststorms occur with high winds moving eastward across the plains, then the regions to the northward in Oklahoma and east Texas suffer from tornadoes. The following reply to this letter has been sent by the Acting Chief and sufficiently explains the reasons for this:

You will find by reference to daily weather maps issued by the Weather Bureau that the duststorms of western Texas occur in the south quadrants of well-marked low barometer areas, or general storms, the centers of which are moving eastward over the States to the northward. On January 27 and 28, the dates to which you refer, the center of a severe storm moved from Colorado eastward over Kansas. The westerly gales experienced in western and northern Texas obeyed the law of the cyclonic circulation of winds. As air moisture is considered essential to the development of tornadoes, the dry air of the plains region does not present the tornadic elements that are found in more eastern districts. To this fact may be ascribed the greater frequency of local storms in eastern Texas and Oklahoma as compared to western portions of Texas.

It is proper to add to the above that, from the beginning of forecasting work, it has always been recognized that tornadoes occur in the southern quadrant of an area of low pressure, so that the forecast that "conditions are favorable for severe local storms" has frequently been published. Thunderstorms also occur most frequently in this quadrant, and so also the hot winds that injure the crops in the region between Texas and Iowa. It is scarcely proper to say that the duststorms of Texas literally change into tornadoes; but it is more proper to say that the conditions favoring the formation of duststorms in Texas will, as they advance eastward, favor the formation of tornadoes in the moister air farther east.—*C. A.*

THE AURORA POLARIS.

In a previous number of the MONTHLY WEATHER REVIEW[1] we have given a brief synopsis of the researches of Prof. Kristian Birkeland and Carl Störmer on the newest views with regard to the nature of the aurora borealis. We are now glad to announce the publication of the first part of two volumes by Birkeland, entitled "The Norwegian Aurora Polaris Expedition, 1902–3, Vol. I. On the cause of Magnetic Storms, and the Origin of Terrestrial Magnetism. First Section."[2]

Being in English we doubt not that this volume will be read by many of the readers of the MONTHLY WEATHER REVIEW, and we can not resist the temptation to reproduce the following clear statement by the author, of the present state of his investigations.—*C. A.*

SUMMARY OF CONTENTS.

By Prof. K. BIRKELAND.

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The knowledge gained, since 1896, in radio-activity has favored the view to which I gave expression in that year, namely, that magnetic disturbances on the earth, and aurora borealis, are due to corpuscular rays emitted by the sun.

During the period from 1896 to 1903, I carried out, in all, three expeditions to the polar regions for the purpose of procuring material that might further confirm this opinion. I have, moreover, during the last ten years, by the aid of numerous experimental investigations, endeavored to form a theory that should explain the origin of these phenomena. It is the results of these investigations that are recorded in this work, the first volume of which treats of terrestrial magnetic phenomena and earth currents, this section forming the first two-thirds of the volume. The second volume will treat of auroras and some results of meteorological observations made at our stations.

The leading principle that I have followed in this work has been to endeavor always to interpret the results of the worked-up terrestrial-magnetic observations, and the observations of auroras, upon the basis of my above-mentioned theory.

Thus, the magnetic storms, for instance, have been studied in such a manner that on the one hand we have formed from our observation-material a field of force which gives as complete a representation as possible of the perturbing forces ex-

[1] Monthly Weather Review, May, 1908, 36:129–131.

[2] This "First Section" is a Royal 4to., 315 pages, 139 figures, and 21 plates.